United Nations A/60/154

General Assembly

Distr.: General
25 July 2005

Original: English

Sixtieth session
Item 54 (f) of the provisional agenda*
Sustainable development

Promotion of new and renewable sources of energy, including the culmination of the World Solar Programme 1996-2005

Report of the Secretary-General

Summary

The accelerated development and increased use of new and renewable sources of energy offer options with multiple benefits for sustainable development. Renewable sources of energy can be used to provide modern energy services to the poor, contribute to meeting the increasing global energy demand, reduce air pollution, mitigate climate change and delay the eventual fossil-fuel depletion. The World Solar Programme 1996-2005 has made a significant contribution to raising awareness of the increased role that new and renewable sources can play in the global energy supply. New and renewable sources of energy have begun entering the mainstream of national and international energy-policy formulation and now constitute an integral element of the global vision for sustainable development. Although gradually increasing, the share of energy now derived from new and renewable sources remains far below its economic potential. Beginning with the World Summit on Sustainable Development, renewable energy has figured prominently in intergovernmental and international meetings. The fourteenth and fifteenth sessions of the Commission on Sustainable Development will focus on energy for sustainable development, atmosphere/air pollution, climate change and industrial development, and will provide an opportunity to formulate the follow-up to the World Solar Programme 1996-2005.

* A/60/150.

05-43818 (E) 170805

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I. Introduction

1. The General Assembly, in its resolution 58/210, reaffirmed the Plan of Implementation of the World Summit on Sustainable Development[1] as the intergovernmental framework for energy for sustainable development and called for its full implementation, including the implementation of recommendations concerning energy for sustainable development. The Assembly encouraged the United Nations system to continue to raise awareness of the importance of energy for sustainable development, including the need for the promotion of new and renewable sources of energy and the implementation of the World Solar Programme 1996-2005, particularly in the context of development and poverty eradication.

2. In welcoming initiatives aimed at improving access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services for sustainable development in order to contribute to the achievement of the internationally agreed development goals, including those set out in the United Nations Millennium Declaration,[2] the General Assembly encouraged national and regional initiatives on renewable energies to promote access to energy, including renewable energy, for the poorest. The Assembly emphasized the need to intensify research and development in support of energy for sustainable development, requiring increased commitment on the part of all stakeholders, including Governments and the private sector, to deploy financial and human resources for accelerating research efforts. The Assembly also stressed that the wider use of available renewable sources of energy requires technology transfer and diffusion on a global scale, including through North-South and South-South cooperation.

3. The General Assembly requested the Secretary-General to submit to it at its sixtieth session a report on the implementation of its resolution A/58/210. The present report, pursuant to that request, provides an overview of recent trends in the development and use of new and renewable sources of energy, of recent advances in new and renewable energy technologies and their applications and of international programmes advancing the use of new and renewable sources of energy, as well as a summary of the World Solar Programme 1996-2005 at its culmination and of follow-up efforts on renewable sources of energy under the Johannesburg Plan of Implementation.

II. Background

4. International interest in new and renewable sources of energy has grown continuously in recent years, motivated by different yet interrelated sustainable-development concerns of significant importance.

5. One of the growing concerns of the international community is the persistent energy poverty that is seriously impeding socio-economic development, particularly in sub-Saharan Africa and in countries of South Asia, but also in many other developing countries, including many of the small island developing States. In the developing countries, some 1.6 billion people still lack access to electricity and about 2.4 billion continue to rely on traditional biomass for cooking and heating, mainly in the rural areas. Achievement of the Millennium Development Goal of halving, by 2015, the proportion of the world's population whose income is less than $1 per day will depend on providing these people with access to modern energy

services for their basic needs and for income generation. Decentralized renewable energy systems can contribute to poverty eradication efforts, in particular in areas with widely dispersed rural populations.

6. Another growing concern is the risk of climate change. Human-induced carbon dioxide and other greenhouse-gas emissions originate principally from the combustion of fossil fuels and from the release of methane during the extraction of natural gas, oil and coal. Expanding the use of new and renewable sources of energy for electricity generation offers options to reduce anthropogenic emissions of greenhouse gases. Many countries have embarked on policies and programmes that seek to expand the use of renewable energy in efforts to mitigate climate-change impacts.

7. Air pollution is also an issue of concern, particularly in large urban and industrialized areas. Local, regional and transboundary air pollution from sulphur and nitrogen oxides, carbon monoxide and suspended particulate matter emanating from fossil-fuel use can cause negative impacts on human health and acid precipitation and contribute to the depletion of the stratospheric ozone layer. The use of renewable energy can have positive environmental impacts through the reduction of local air pollution.

8. There continues to be a need for more energy from all sources, including renewable sources. Developing countries in particular are faced with rising energy demand as a result of expanding per capita economic activity and increasing populations.

9. Finally, and with a longer-term perspective, the issue of natural-resource depletion should not be overlooked. Fossil-fuel reserves — especially oil, but also natural gas and coal — are ultimately finite natural resources. Together with greater energy efficiency, greater reliance on advanced energy technologies and a more sustainable use of traditional energy sources, new and renewable sources of energy will have to make a greater contribution to the future energy-supply mix if the rising global energy demand is to be met, and if energy costs, which are often projected to rise considerably in the future, are to remain at affordable levels.

III. Culmination of the World Solar Programme 1996-2005

10. In September 1996, the United Nations Educational, Scientific and Cultural Organization (UNESCO) organized the World Solar Summit in Harare. Eighteen heads of State or Government attending the Summit constituted the World Solar Commission, adopted the Harare Declaration on Solar Energy and Sustainable Development and launched the World Solar Programme 1996-2005, which was endorsed by the General Assembly in its resolution 53/7, to be implemented with the provision of secretariat assistance by UNESCO.

11. As the initiator of the World Solar Programme 1996-2005, UNESCO provided the international community with an instrument for the promotion of renewable forms of energy.[3] In the spirit of that programme, a considerable number of industrialized and developing countries initiated and implemented local and national projects using energy from renewable sources. National programmes included assessment studies of renewable energy potentials, large-scale as well as small-scale investment projects in electricity generation using renewable sources of energy, and

national institution-building initiatives such as the creation of national renewable energy agencies, as well as capacity-building, training, advocacy and public information initiatives.

12. The contribution of UNESCO to the implementation of the World Solar Programme 1996-2005 included a series of capacity-building projects and initiatives aimed at the dissemination of relevant scientific knowledge and technology. The aim of its Global Renewable Energy Education and Training Programme, which places special emphasis on Africa, is to improve the use of renewable sources of energy through better project management and operation, as well as the transfer of technological know-how through continuing and distance education and training activities targeting energy-policy decision makers, researchers, engineers, university educators and technicians. Under the programme, learning and teaching packages, textbooks and brochures on renewable energy have been prepared, field-tested and disseminated. UNESCO has carried out a number of training activities for the benefit of participants from developing countries, particularly those from African nations. UNESCO activities under the World Solar Programme 1996-2005 were frequently undertaken in cooperation with other organizations, including the International Solar Energy Society (ISES).

13. While the initial plan of the programme was quite ambitious, with a vast array of projects proposed, the number of projects eventually funded did not meet early expectations. Nevertheless, the World Solar Programme 1996-2005 was an important global initiative that has raised awareness of the increased role renewable sources can play in the global energy supply. A major impact of the Programme is that, during the period of its implementation, new and renewable energy sources have begun entering the mainstream of national and international energy-policy formulation and now constitute a major element of the global vision for sustainable development.

IV. Renewable energy and the Plan of Implementation of the World Summit on Sustainable Development

14. The promotion of new and renewable sources of energy figured prominently in the deliberations of the World Summit on Sustainable Development. The actions called for in the Johannesburg Plan of Implementation include a major focus on energy for poverty eradication, for changing unsustainable patterns of consumption and production and for the sustainable development of regions, including Africa and the small island developing States.

15. In addressing the contribution that renewable energy can make to poverty eradication, the Plan calls for (a) increased use of energy from renewable sources as one means of improving access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources, (b) improved access to modern biomass technologies and fuelwood sources and supplies, and commercialized biomass operations in rural areas and where such practices are sustainable, and (c) improved patterns of use through better management of resources, more efficient use of fuelwood and new and improved products and technologies aimed at promoting sustainable use of biomass and, as appropriate, other renewable sources of energy.

16. With regard to the need to change unsustainable patterns of consumption and production, the Plan calls for substantially increasing, with a sense of urgency, the global share of energy obtained from renewable sources, hydro included, with the objective of increasing its contribution to the total energy supply, and regularly evaluating available data to review progress to this end.

17. The Plan also calls for support for initiatives to increase the use of renewable energy, particularly in rural and peri-urban areas, and to support the efforts of African nations to achieve the goals of the New Partnership for Africa's Development, one of which is to secure access to energy for at least 35 per cent of the African population within 20 years, especially in rural areas.

18. The report of the International Meeting to Review the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States, held in Port Louis, in January 2005, points out that energy dependence is a major source of economic vulnerability for these nations, with many remote and rural small island developing communities having little or no access to modern and affordable energy services. The report, noting also that many small island developing States are particularly suited to the use of renewable sources of energy because of their geographical location, affirms that these States are committed, with the required support of the international community, to strengthening ongoing and supporting new efforts in the areas of energy supply and services.

V. Trends in the development and use of new and renewable sources of energy

19. During the past decade, the international community has contributed much to increasing awareness that multiple benefits — economic, social, and environmental — can result from accelerated development and increased use of new and renewable energy sources. This has prompted considerable national and international efforts to promote renewable energy development, including those under the World Solar Programme 1996-2005. There is now a discernible trend towards greater policy support in several developing countries. In such countries as Brazil, China, India and the Philippines, national-level programmes and institutional arrangements have been established for renewable energy development. However, in many other developing countries, programmes are still too small to have a significant impact on their national energy systems, due largely to lack of access to affordable new and renewable energy technologies. Most Organization for Economic Cooperation and Development countries have instituted concrete measures and adopted ambitious plans and targets, with particularly strong efforts in Europe, Japan and the United States of America. Under these programmes, a variety of projects have been implemented by national as well as local authorities, often in partnership with public-sector agencies, private-sector companies, non-governmental organizations, commercial banks, guarantee agencies and microfinance organizations.

20. The overall trend in the development and use of new and renewable sources of energy is towards significant expansion, as shown for the various geographical regions in table 1 for electric power generated from renewable energy sources, which is a good indicator of the major non-transport consumption of renewable sources of energy using modern technologies other than hydropower, which is the

focus of table 2. While the share of hydropower-generated electricity consumed has remained relatively constant overall and started to decrease in the industrialized regions where some dams have been decommissioned in response to ecological concerns, development of this resource has been strong in Africa and West Asia. With regard to transportation, the use of fuel ethanol and other fuels from biological resources is also growing at a significant rate, as shown in table 3.

Table 1
World geothermal, solar, wind, and wood and waste electric power consumption by region, 1985-2003

(Billions of kilowatt-hours)

	1985	*1990*	*1995*	*2000*	*2003*
North America	12.32	71.65	83.35	93.29	102.07
Latin America and the Caribbean	8.44	13.12	16.66	23.45	31.94
Western Europe	13.81	19.39	38.03	75.01	110.35
Central and Eastern Europe and States of former Soviet Union	0.51	0.31	2.37	3.83	4.71
West Asia	—	—	0.001	0.003	0.01
Africa	0.37	0.39	0.43	0.90	1.01
Asia and the Pacific	20.05	26.69	36.62	53.03	60.01
Total	**55.50**	**131.54**	**177.47**	**249.49**	**310.10**

Source: Energy Information Administration, United States Department of Energy, June 2005, arranged according to the regions of the United Nations; see www.eia.doe.gov.

Table 2
World hydroelectric power consumption by region, 1985-2003

(Billions of kilowatt-hours)

	1985	*1990*	*1995*	*2000*	*2003*
North America	585.11	586.73	643.40	630.24	608.27
Latin America and the Caribbean	313.43	388.37	487.00	578.85	581.09
Western Europe	453.15	453.42	508.49	554.90	483.74
Central and Eastern Europe and States of former Soviet Union	228.63	251.72	268.14	258.04	266.33
West Asia	3.22	6.52	8.33	10.58	12.53
Africa	46.50	54.82	58.87	73.96	84.96
Asia and the Pacific	323.53	410.12	486.29	545.21	615.98
Total	**1 953.57**	**2 151.72**	**2 461.29**	**2 651.76**	**2 654.37**

Source: Energy Information Administration, United States Department of Energy, June 2005, arranged according to the regions of the United Nations; see www.eia.doe.gov.

Table 3
World fuel ethanol and biodiesel production by region, 1985-2003
(Billions of litres)

	1985	1990	1995	2000	2003
North America	2.3	3.5	5.3	6.4	11.9
Latin America and the Caribbean	1.7	1.8	12.6	10.9	13.7
Western Europe	—	—	0.4	1.0	3.2
Central and Eastern Europe and States of former Soviet Union	—	—	—	0.1	0.1
West Asia	—	—	—	—	—
Africa	—	—	—	—	—
Asia and the Pacific	—	—	—	—	1.3
Total	**14.1**	**15.2**	**18.3**	**18.4**	**30.1**

Source: F.O Licht's World Ethanol and Biofuels Reports (2003-2005).

21. However, despite the marked overall increase in the development and use of new and renewable sources of energy, and in their share of the total energy mix, the magnitude of that share remains quite small. All renewable forms of energy (including large hydropower and non-commercial biomass) were estimated to provide in 2002 only 13.4 per cent of the global primary energy supply, with 2.2 per cent from hydropower (of all sizes), 10.8 per cent from combustible renewables, which were mainly fuelwood and charcoal, and 0.5 per cent from geothermal, solar, tidal and wind energy.

22. From the annual growth rates for the energy supplied from the various renewable sources averaged over the period from 1990 to 2002 shown in table 4, a significant difference in the development of each source is evident. The amount of energy supplied by solid biomass, geothermal energy and hydropower sources grew only 10 to 30 per cent faster than the total primary energy supplied. However, solar and wind energy sources and renewable municipal solid waste, biogas and liquid biomass proved to be significant growth areas for renewable energy use, as the technologies to exploit them continue to undergo rapid development.

Table 4
Annual growth rates of energy supplied from renewable sources from 1990 to 2002

(Percentage)

All primary energy sources	1.4
All renewable energy sources	1.7
Wind	23.9
Solar	6.4
Hydropower	1.6
Geothermal	1.8
Solid biomass	1.6
Renewable municipal solid waste, biogas and liquid biomass	7.4

Source: Renewables Information, International Energy Agency, Paris 2004

VI. Recent advances in new and renewable energy technologies and their applications

23. In support of resolution A/58/210, many countries have intensified research and development efforts in support of energy for sustainable development, including energy from renewable sources. In fact, development of renewable energy spans the full range of sectors, application, and technologies, including electricity supply using grid and off-grid means, and a variety of wind, solar photovoltaic, biomass co-generation, biogas co-generation, hydropower, tidal and geothermal solutions.

24. The modern renewable energy technologies, such as wind turbines, modern biomass systems, modern biofuels[4] and solar photovoltaics (PV), are receiving increasing support in many developing and industrialized countries. Markets are currently expanding at an annual rate of about 30 per cent for wind energy and about 20 per cent for solar photovoltaics and these have experienced significant cost reductions over the years.

Wind power

25. Grid-connected wind power is regarded as a major success in renewable energy applications on the basis of technological maturity and commercial attractiveness. The installed capacity worldwide, at the end of 2004, reached 47,000 megawatts and is poised to exceed 100,000 megawatts by 2010. Worldwide investment in wind power installations was approximately $9 billion in 2003, corresponding to a capacity addition of nearly 8,100 megawatts in that year. The historical trend in cost reduction has also been quite impressive. Wind power now costs less than $0.05 per kilowatt-hour at good windy sites. Over the last 15 years, the annual energy output per turbine unit has increased 100-fold, and turbine capacity for typical commercial machines has increased from 55 kilowatts to over 3 megawatts. In the past five years, the weight of a wind turbine per kilowatt of installed power has been halved. The total installed capacity has increased more than 15-fold in the last 10 years. Taken as a whole, wind power has emerged as a

key renewable energy technology whose cost is competitive with the average cost of conventional power.

26. The support provided by Governments has influenced development patterns, particularly in Denmark, Germany, India, the United Kingdom of Great Britain and Northern Ireland and the United States of America. Many developing countries have major plans for harnessing wind power. India already has an installed capacity of over 3,500 megawatts and China has installed more than 964 megawatts so far under a major wind-power development programme.

27. With continued innovation in site optimization, generator design and power electronics, further cost reduction is expected, although the pace may not be as rapid. Recent developments include improvements in variable-speed and gearless wind machines, and wind turbines are now able to operate efficiently at lower wind speeds, which opens the use of wind power to sites that were previously considered uneconomical. In addition to the installation of wind power units onshore, a trend is emerging to develop offshore sites. Developing countries face the challenge of establishing national capacities to undertake such offshore projects. Environmental issues surrounding wind energy pertain to noise, television and radio interference, danger to birds and visual effects, and care needs to be exercised in siting to avoid these problems. Many utility studies have indicated that wind can be readily incorporated into an integrated power network until its share reaches 20 per cent of maximum demand. With continuing improvements in performance and costs and appropriate support, both nationally and internationally, the global installed wind capacity is likely to increase significantly.

Solar photovoltaics

28. Like wind-power technology, solar photovoltaics (PV) have also experienced rapid growth in diverse applications. Advances in technology, and the gradual expansion of production capacity worldwide, as well as numerous demonstration projects undertaken during the 1990s, have contributed to the development of the PV market. Costs have fallen substantially over the years. However, the market for PV and the total installed capacity are much smaller than those for wind power. The cumulative installed PV capacity is estimated to be about 3,000 megawatts, with about 1,000 megawatts shipped last year. The cost of PV remains at least 5 to 10 times that of grid electricity. Nevertheless, for small power applications in rural and remote areas, PV has established itself as a cost-effective alternative to grid extension or diesel-powered generation.

29. A number of developing countries have been promoting solar home systems and mini-grids in rural areas far from electrical grids, for lighting, communications and productive uses. In addition to national efforts, support provided by the World Bank Group is estimated to have provided PV-based electricity services to an estimated 1.2 million households, enterprises and community facilities that lack access to grid electricity, at a cost of more than $700 million. Some developing countries such as Brazil, China, India and the Philippines, have established significant technical and industrial capacity. Several African countries, notably Kenya, Uganda and the United Republic of Tanzania, have each facilitated access to decentralized PV electrification for more than 100,000 consumers, including households. Grid-connected PV applications are also increasing as a result of developments in efficient grid interfacing technologies and the wider use of net

metering facilities. Several megawatt-scale PV systems have been installed in Europe and the United States of America.

30. PV technologies are still evolving, and no clear trend has emerged with regard to the choice between crystalline silicon technologies and thin-film technologies. Recent advances and developments in other areas of PV technology include organic semiconductor-based solar cells on flexible plastic substrates, nanotechnology-based and quantum-dot PV systems, light-absorbing dye-based and photoelectrochemical systems and building-integrated photovoltaic designs.

31. While most of these advances are still at the research stage, for some the potential for commercial-scale operations is promising. The achievement of a substantial cost reduction for any of these technologies would provide the opportunity for rapid expansion of PV applications.

Hydropower

32. For the supply of electricity, large hydropower sites are the primary sources of renewable energy in both industrialized and developing countries, contributing approximately 20 per cent to electric power generation worldwide, while utilizing about one third of the economically exploitable potential of that resource. Hydropower projects have the advantage of avoiding emissions of greenhouse gases, SO_2 and particulates. Their social impacts, such as land transformation, displacement of people and impacts on fauna, flora, sedimentation and water quality, can be mitigated if appropriate steps are taken early in the planning process. As there remains considerable resource potential, particularly in the developing regions, hydropower can make a significant contribution to sustainable development when all these aspects are carefully managed. The United Nations Symposium on Hydropower and Sustainable Development in Beijing in October 2004, organized jointly by the United Nations Department of Economic and Social Affairs, the World Bank and the Government of China, and attended by 500 participants from national and local governments, utilities, the private sector, multilateral financial and other international organizations, non-governmental organizations, the scientific community and international industry organizations, concluded with a declaration emphasizing the need for developing hydropower resources in a manner that is economically, socially and environmentally sustainable.

Geothermal energy

33. Geothermal energy has now been tapped in 24 countries. In 2003, geothermal resources supplied 57,000 gigawatt-hours of electricity, an increase of 50 per cent from 1995. El Salvador, Iceland and the Philippines generate 25 per cent or more of their electricity needs from geothermal sources. Several countries are moving ahead with new developments, particularly Indonesia and the Philippines. Iceland, Italy, Japan and New Zealand have long provided international training opportunities in geothermics for developing countries in cooperation with the United Nations, and were recently joined by the former Yugoslav Republic of Macedonia.

Modern biomass and conversion technologies

34. While traditional uses of biomass continue to play a significant role for low-income populations in developing countries, the trend in applications worldwide is increasingly shifting to modern biomass and conversion technologies. The

modernization of biomass use relates to a range of technological options, such as gasification, co-firing with fossil fuels, micropower, tri-generation and ethanol. Biomass gasification and biomass-to-liquid fuel technologies that can produce ethanol and biodiesel, together with sustainable management of biomass resources, open a major role for biomass, especially in the transportation sector, where it can directly substitute for fossil fuels. The use of modern biomass systems for heat and electricity generation is expanding rapidly in industrialized countries. For example, it contributes about 11 per cent of primary energy in Austria, 20 per cent in Finland and 4 per cent in the United States of America. Worldwide electricity production capacity based on commercial biomass exceeds 40,000 megawatts. As a result of significant market experience, these systems have attracted attention in several developing countries, notably Brazil, China and India.

35. National and international efforts have contributed much to the significant progress in addressing the environmental problem caused by fuelwood use through the introduction of a variety of locally compatible fuelwood stoves that improved efficiency from 5 per cent to 20 to 30 per cent in the two decades, during which an estimated 100 million such stoves were introduced.

36. Worldwide production of ethanol has doubled since 1985, reaching about 30 billion litres per year in 2003. Brazil — which has had a major fuel ethanol programme for over 25 years that now operates on a commercial basis without subsidies — and the United States of America account for more than 90 per cent of the total, with production growing in Western Europe, as well as in Canada, China, India and Zimbabwe. New programmes to produce commercial quantities of fuel ethanol are also under way in Australia, Colombia, Costa Rica, Guatemala, Honduras and Nicaragua, some with an interest in exporting.

37. Worldwide, Western Europe has the highest biodiesel production capacity; in 2003 it reached about 1.5 billion litres per year compared with the world production capacity of 1.7 billion litres per year. The fuel is used mainly as a diesel blend, typically at the rate of 5 or 20 per cent. However, in Germany, biodiesel is commonly sold in its 100 per cent neat form and dispensed in about 700 filling stations. Indonesia, Malaysia and the Philippines are planning to expand biodiesel production based on palm and coconut oils.

38. Research is now under way to find ways to reduce the land-use conflicts involved in ethanol production from grain by developing techniques that exploit the cellulose route to ethanol production, in which any plant feedstock can be used, with gasification of the biomass followed by conversion of the gas into liquid fuels such as ethanol, methanol, synthetic diesel, gasoline and dimethyl ether (a potential alternative fuel for diesel engines). Although still under development, fuels produced by some of these techniques are expected to become commercialized in the foreseeable future. For some countries, biofuels offer a way to achieve greater energy security through diversification and provide environmental benefits as well. A number of land utilization, environmental and societal issues, as well as internal and external trade issues, pose challenges to the scaling up of liquid biofuel production to achieve national and global impacts.

Hydrogen

39. The international community recognizes that hydrogen could be a key component in a clean, sustainable energy system, popularly referred to as the

hydrogen economy. Such a system features hydrogen as the major energy carrier for stationary power, transportation, industry, residences and commerce. However, in order for such a system to be environmentally friendly, the primary energy source will have to be renewable. The hydrogen produced can be stored, transported by truck or pipeline and used in fuel cells, turbines and engines to generate electric power, with water as the principal by-product.

40. Progress towards a hydrogen economy is advancing. In 2003, automobile companies collectively adopted the concept of storing hydrogen on board for a fuel-cell vehicle. Iceland produces hydrogen using geothermal energy and hydropower, both indigenous renewable energy sources, and its Government announced plans to further expand renewable energy use towards the ultimate goal of a national hydrogen economy. The Government of Norway is considering plans for making this fuel from wind and hydropower resources.

41. A major research and development initiative on hydrogen fuel-cell technology has been under way in Japan for more than two decades, with current efforts focusing on the commercialization of hydrogen fuel cells and studying the use of offshore floating wind farms to produce hydrogen for piping to markets onshore. The United States Government has allocated $1.7 billion over the next five years for the advancement of hydrogen, fuel-cell and hybrid-electric vehicle technologies and to support the necessary infrastructure for these vehicles. In 2003, the European Commission launched a €2.8 billion initiative that incorporates a 10-year programme for hydrogen-related research, production and use, and also recently unveiled a €2 billion hydrogen vision designed to bring hydrogen technologies, including fuel cells, closer to large-scale commercial viability based on renewable resources by 2050. Hydrogen fuel research is also actively pursued in Switzerland. Among the developing countries, Brazil, China and India have national hydrogen research and development programmes. The Indian programme focuses on the production, storage and use of hydrogen, and has already demonstrated the use of gasifiers for converting woody biomass into hydrogen to fuel electric generators for village power in remote areas and the use of hydrogen and natural gas blends for operating vehicles. Challenges to the development of the hydrogen economy include the establishment of the fuel distribution infrastructure, the improvement of hydrogen storage systems and a reduction in the cost of fuel cells.

Mixed energy sources

42. In some countries, national renewable energy programmes are comprehensive and support the development of a mix of energy sources. The Government of the United Kingdom of Great Britain and Northern Ireland, for example, is supporting the demonstration of renewable technologies not yet fully developed or financially competitive. Between 2002 and 2008, the United Kingdom Government will provide £500 million for the development of emerging renewable and low-carbon technologies, including grants of over £60 million for energy crop and biomass projects and £31 million for PV systems. In 2004, the Government announced the establishment of a special £50 million fund that is largely earmarked to support a large-scale demonstration that for the first time will feed power from wave and tidal energy into the national grid. The commitment of the Government of China is equally comprehensive. In addition to its massive hydropower projects, China has a total installed capacity of 34 million kilowatts of small hydropower facilities (<50 kilowatt) providing electricity to 300 million people in the remote and

mountainous areas of 30 of its 32 provinces; 60 million square metres or 40 per cent of the world's installation, of solar water heaters; wind farms with an installed grid-connected capacity of nearly 0.76 megawatts; and a new renewable energy law delineating the responsibilities of various government agencies and requiring the establishment of measures to encourage power generation from renewable sources. Plans call for small hydropower installations to double by 2020, solar water heaters to increase by 12 million square metres annually, wind power installations to increase 50-fold by 2020 as a result of new concession bidding arrangements, and the country as a whole to derive 10 per cent of its primary energy supply from renewable sources by 2020.

Policy tools and measures

43. Governments use a variety of policy tools and measures to promote renewable energy use. In the United States of America, national laws were enacted in 1978 to enhance competition in electricity supply by requiring utilities to buy electricity from co-generators and smaller-scale renewable energy producers at the utilities' avoided cost, and to provide investment tax credits for residential and business consumers who install facilities producing electricity from renewable sources. In 1992, another such law provides the basis for direct financial incentives for investment in renewable energy technologies, some of which are still available to investors today. Recently, local governments have been motivated, largely by environmental concerns, to enact laws promoting the use of renewable sources of energy. For example, 28 states of the United States of America have adopted or are considering the adoption of renewable portfolio standards to ensure that a certain minimum portion of the electricity serving that state comes from renewable sources, and many United States counties and municipalities provide further incentives that promote these sources. The European Union is pursuing a target for its member States of 10 per cent of electricity from renewables by 2012 and 20 per cent by 2020. In many of its member countries, electricity feed-in and renewable energy laws are among the main tools used to encourage private investment in renewable energy development by obliging utilities to buy power from producers of renewable energy at commercially attractive higher-than-market rates. Other tools used to promote renewable energy include government purchasing or bidding systems; differential production; investment, sales and excise taxes; tax credits, exemptions and rebates; tradable certificates; third-party financing; green pricing; net metering; and consumer grants or rebates. Recent studies have shown that policy measures aimed at promoting renewable energy utilization can have positive impacts by stimulating renewable energy investment, equipment production, trade and development.

VII. International programmes for advancing the use of new and renewable sources of energy

44. Many renewable energy projects have high-capital investment requirements. Among other factors affecting the economic viability of renewable-energy projects, long-term capital costs are of paramount importance. International financial institutions play a crucial role in mobilizing the necessary financial resources, in particular for large-scale investments, but also for supporting national lending institutions and small-scale revolving loan funds. This is crucial for those

developing countries, particularly in Africa, that continue to face constraints in responding to the call for substantially increasing the share of renewable energy in their energy-supply mix largely because of limited capacity and lack of access to technologies and financing.

45. The World Bank Group, consisting of several institutions, plays a particularly prominent role in international cooperation for development financing. The International Bank for Reconstruction and Development (IBRD) works to reduce poverty in middle-income countries by promoting sustainable development, through loans, guarantees and technical advisory services. Renewable energy and energy efficiency are the focus of a significant and growing number of IBRD projects. Donor contributions to the International Development Association (IDA) enable the World Bank to provide $7 billion each year in concessional lending to more than 80 low-income countries with an estimated population of 2.5 billion people for access to improved basic services, productivity growth and employment creation. Renewable energy and energy efficiency components are included in a number of IDA-funded initiatives that focus on poverty alleviation and economic development. The mandate of the International Finance Corporation (IFC) is to further economic development through the private sector. IFC invests in projects and in regions and sectors underserved by private investment and finds innovative financing modalities and business models to develop opportunities in markets deemed too risky by commercial investors in the absence of its participation. IFC has a growing portfolio of renewable energy projects. The Multilateral Investment Guarantee Agency (MIGA) encourages foreign investment in developing countries by providing guarantees to foreign investors against losses caused by non-commercial risks. Risk guarantees by MIGA have made it possible for the private sector to undertake renewable energy projects that otherwise would not have proceeded.

46. A further important source of multilateral funding for renewable and energy efficiency projects is the Global Environment Facility (GEF). GEF is the incremental financing mechanism for a range of international environmental agreements, providing support for projects that have a global environmental benefit.

47. The financial commitments of the World Bank Group, summarized in table 5, have contributed considerably to a steady and accelerating investment in and production of energy from new and renewable sources. However, in many of the developing countries, and particularly in rural areas, small-scale energy entrepreneurs and cooperatives still face obstacles in securing financing for viable project proposals. More innovative financing arrangements for smaller-scale projects and further upscaling and replication of successful renewable energy projects will be important for the achievement of the goals of the World Summit on Sustainable Development.

Table 5
World Bank Group renewable energy and energy-efficiency commitments since 1990

(Millions of United States dollars)

	Renewable energy	*Energy efficiency*	*Total*
IBRD and IDA	1 320	1 734	3 054
IFC	752	93	845
GEF	694	363	1 057
Total	**2 766**	**2 190**	**4 956**

Source: Renewable Energy for Development, World Bank Group, Washington, D.C. (May 2004); see www.worldbank.org.

48. The continued commitment of the World Bank Group to the practical, effective and direct promotion of new and renewable sources of energy is also manifested in the recent decision to rely on renewable energy for 100 per cent of the power needs of its headquarters in Washington, D.C.

49. Together with the bilateral programmes of other donors that support investments in energy and sustainable development, the European Union Energy Initiative and the Energy Facility for African, Caribbean and Pacific developing countries can also be expected to stimulate the mobilization of new resources for renewable energy development in those regions.

50. Several organizations of the United Nations system support developing country efforts to expand the use of energy from renewable sources. At the request of many developing countries, the Department of Economic and Social Affairs of the United Nations Secretariat has provided technical and policy advisory services, including projects in China for commercializing renewable energy technologies; in several small island developing States for the practical application of solar energy systems; and for strengthening renewable energy development capacities in several Arab States, including assistance to the Syrian Arab Republic in preparing a comprehensive renewable-energy master plan. With funds from the Human Security Fund, supported by Japan and the United Nations Foundation, the Department of Economic and Social Affairs has recently implemented projects in the Gambia, India and Timor-Leste, adopting an integrated approach to capacity-building involving productive activities, community development and improvement of basic water and energy infrastructure. The Department of Economic and Social Affairs programme focuses on promoting policies that increase access to energy for sustainable development through the exploitation of renewable sources of energy.

51. UNESCO has provided support for national and regional training activities in Africa, Asia and Latin America and the Caribbean, as well as for such recent major conferences as the World Wind Energy Conference and Renewable Energy Exhibition, in Beijing; the World Renewable Energy Congress and Exhibition 2005 for Asia and Africa, in Jakarta; and the 20th European Photovoltaic Solar Energy Conference and Exhibition, in Barcelona. In addition, UNESCO has supported regional networks such as the International Network for Sustainable Energy, launched in collaboration with the Energy Institute of French-Speaking Countries

and the European Network on Education and Training in Renewable Energy Sources, a regional voluntary cooperative framework uniting universities and other educational and academic institutions in Europe.

52. One of the selected programme goals being pursued by the United Nations Development Programme (UNDP) is the expansion of access to sustainable energy services, with the aims of establishing national policy frameworks that reflect the role of energy in poverty reduction and sustainable development; increasing access to energy services, electricity or cleaner fuels in rural areas; introducing low-emission energy technologies, including renewable energy; and expanding access to energy-investment financing through the Clean Development Mechanism and public-private partnerships. In 2004, 153 full-scale projects in renewable energy were implemented by UNDP with a total value of $556 million, including cost-sharing. Support for developing national renewable energy strategies was provided in Bolivia, Chile, Peru, the Philippines, the Syrian Arab Republic, Thailand and Uzbekistan. A considerable number of sustainable-energy development and renewable-energy promotion projects were supported by GEF, including large projects undertaken by UNDP in Bolivia, Mexico, Slovenia, Thailand and Tunisia, each with a budget of between $4 million and $12 million. In addition, UNDP has been managing the GEF Small Grants Programme, which has so far supported approximately 820 practical small-scale projects.

53. The United Nations Environment Programme (UNEP) addresses the environmental consequences of energy production and use, such as global climate change and local air pollution. UNEP promotes policies that place energy and transport within the broader sustainable development context and steers project developers and investors towards greater engagement in renewable-energy and energy-efficiency programmes. UNEP and its two collaborating centres, the Risø Centre on Energy, Climate and Sustainable Development and the Basel Agency for Sustainable Energy, work with a wide range of stakeholders to, inter alia, diversify and increase the global share of renewable energy sources, improve access to environmentally sound energy resources and services, remove market distortions, provide access to energy markets and accelerate the development and dissemination of better methods and technology. The larger UNEP programmes that are focused on renewable energy include the Rural Energy Enterprise Development Programme, the Sustainable Energy Finance Initiative and the Indian Solar Loan Programme. UNEP also supports and participates in international partnerships such as the Mediterranean Renewable Energy Programme, works on capacity-building together with export credit agencies and is involved in the Capacity Development for the Clean Development Mechanism project.

54. The Food and Agriculture Organization of the United Nations (FAO) continues to assist developing countries through policy advice, projects and technical advisory services to meet their energy requirements in agriculture, forestry and fisheries, as a means of achieving sustainable development. The energy activities of FAO are carried out in cooperation with many different regional and international partner organizations and are implemented through its network of over 80 national, regional and subregional offices. FAO activities seek to promote a progressive transition from the present energy supply, consisting mainly of fuelwood and other biomass fuels and of animal and human power, to a more diversified resource base that includes other renewable energy sources and more modern uses of biomass. FAO activities include field projects aimed at increasing the supply of biofuels, reducing

inefficient fuelwood consumption and promoting rural electrification based on renewable energy, while seeking to attain sustainable livelihoods and gender equality and improve the living conditions of rural populations.

55. In promoting new and renewable energy development, technology dissemination and application, the United Nations Industrial Development Organization (UNIDO) provides technical assistance and capacity-building support to expand the productive use of small hydropower, sustainable biomass energy, solar photovoltaic power and thermal energy, and wind energy, in particular for the benefit of rural areas in developing countries. UNIDO promotes renewable energy entrepreneurship, the manufacture of renewable energy equipment and rural industrialization using renewable energy in several countries in Africa, Asia and Latin America.

56. Projects and programmes that promote the development and use of renewable sources of energy are also being implemented by several of the United Nations regional economic commissions. The contribution of renewable energy technologies to poverty alleviation has been the main focus of studies by the Economic Commission for Africa, including innovative financing mechanisms to facilitate access to energy services for the poor. The Economic and Social Commission for Asia and the Pacific has supported a pilot mini-hydropower project in Indonesia involving a public-private partnership for providing basic energy services to the rural poor. One focus of the Economic Commission for Latin America and the Caribbean is on preparing studies on the potential and use of new and renewable sources of energy in the region. The promotion of renewable energy is also a core activity at the Economic and Social Commission for Western Asia, which disseminates information on renewable energy technologies in the context of water desalination and rural electrification.

57. Collaborative arrangements on energy among the relevant departments, programmes and agencies of the United Nations are expected to benefit from and expand with the recent establishment of UN-Energy. Following a decision by the United Nations System Chief Executives Board for Coordination pursuant to the recommendation of the High-level Committee on Programmes, UN-Energy was established in June 2004 as a system-wide collaborative arrangement on energy. During the start-up phase, the 19 participating UN-Energy members have prepared an inventory of ongoing work to identify areas for cooperation. With regard to the promotion of new and renewable sources of energy, the International Atomic Energy Agency, the Department of Economic and Social Affairs, FAO, UNDP, UNEP and UNIDO are jointly initiating a UN-Energy modelling project that seeks to provide countries with a practical computer model toolkit to quantitatively project and assess the contribution of alternative renewable energy policy measures to the goal of increasing the share of energy from renewable sources in the total energy supply. Another joint effort, led by FAO, is undertaking an assessment of and supports capacity-building in the area of bioenergy.

58. International partnerships, non-governmental organizations and other stakeholders that promote the development of new and renewable sources of energy also contribute significantly to advancing the Johannesburg Plan of Implementation. The Renewable Energy and Energy Efficiency Partnership (*REEEP*) works to structure policy initiatives for clean energy markets, facilitate financing for sustainable energy projects and support the creation of new sources of finance.

Recent REEEP projects have established private energy-market funds to provide capital for sustainable-energy investments in South-East Asia and an innovative private equity and guarantee facility for clean energy for small hydropower projects in Brazil.

59. In November 2003, energy ministers from 15 countries and the European Union, representing 85 per cent of the world's gross domestic product, announced the creation of the International Partnership for a Hydrogen Economy (IPHE), an important global effort to maximize collaborative partnerships among countries and to promote the conduct of advanced research on hydrogen and fuel-cell technologies and the sharing of the results. The Government of Iceland, a member of IPHE, has offered Iceland as an international platform for hydrogen research and experimentation with a view to facilitating the sharing of its pioneering experiences.

60. Of the 308 international partnerships currently registered with the secretariat of the Commission on Sustainable Development, 77 involve energy for sustainable development, of which 16 have a major focus on renewable energy, including the Global Village Energy Partnership, led by UNDP and the World Bank; the Global Network on Energy for Sustainable Development, led by UNEP; the 100% Renewable Energy Islands partnership, involving the Governments of Fiji, Tonga and Tuvalu; the Mediterranean Renewable Energy Programme, led by the Italian Ministry of the Environment; the Modern Biomass Technology for Rural Energy Needs partnership, involving the Governments of France and Madagascar; the Renewable-Energy-Based Rural Electrification Initiative, led by the Pacific International Center for High Technology Research of the United States of America; and the Sustainable Energy for Sustainable Development in the Caribbean partnership, led by the Caribbean Community secretariat.

61. Several recent international conferences have been organized to highlight the benefits and promote the increased use of renewable sources of energy. In particular, the Government of Germany hosted the International Conference for Renewable Energies in Bonn in June 2004. At the Conference, ministers and government representatives from 154 countries adopted a Political Declarations and committed their Governments to an International Action Programme aimed at increasing investments in electricity generation based on renewable energy sources, bringing about access to energy for a large number of people and reducing CO_2 emissions. Similarly, perspectives for interregional cooperation among developing countries in the promotion of renewable sources of energy were highlighted at the Asian-African Symposium on Renewable Energy, held in Jakarta in April 2005 in conjunction with the Asia-Africa Summit 2005. Symposium participants agreed to build a people-centred, inclusive and development-oriented Community of Renewable Energy of Asia-Africa in the spirit of the New Asian-African Strategic Partnership agreed upon by the heads of State in attendance at the Summit. Moreover, specialist technical conferences have provided important forums for the exchange of information on project experiences and technology advances in hydropower, biomass, wind, solar, geothermal and other forms of electricity generation based on renewable sources.

VIII. Conclusions: prospects for the future

62. International efforts to expand access to energy for the poor, reduce air pollution, mitigate climate change and expand the energy resource base are serving to increase international awareness of the benefits available from renewable energy development and utilization. In recent years, the use of new and renewable sources of energy has accelerated, and policymakers in many countries have taken or initiated action to promote the increased utilization of these energy sources. Public utilities, the private sector, international partnerships and non-governmental and community-based organizations have all contributed to increasing investments in renewable energy. Whereas in the industrialized countries the production and use of biofuels and electricity generation from wind and solar energy have grown substantially, developing countries have added most of their additional renewable energy capacities from hydropower.

63. Although the share of energy derived from new and renewable sources is gradually increasing, the total share of commercial energy derived from these sources still remains far below its economic potential. According to the latest available estimates, the share of new and renewable energy in the total global energy supply, including large hydropower but not including combustible renewables and waste, has yet to reach 3 per cent.

64. Thanks also to the awareness raised by the World Solar Programme 1996-2005, interest in new and renewable sources of energy has intensified. The topic is reflected in the Gleneagles Plan of Action on Climate Change, Clean Energy and Sustainable Development resulting from the Group of Eight Summit of 2005. Among the concrete action points, the Group of Eight will promote the International Action Programme of the 2004 International Conference for Renewable Energies, held in Bonn, Germany, through a new conference to be jointly organized by the Governments of China and Germany, facilitated by the Department of Economic and Social Affairs and held in Beijing at the end of 2005. Moreover, the entry into force of the Kyoto Protocol of the United Nations Framework Convention on Climate Change offers the prospect of financing the development and use of new and renewable sources of energy in developing countries under the Clean Development Mechanism. Thus, more intensive efforts to develop and utilize new and renewable sources of energy may be envisaged.

65. There remain large segments of developing-country populations that still do not have access to modern forms of energy, while many indigenous energy sources, including renewable ones, remain untapped. Increased local, national and international efforts will be needed to achieve the renewable energy elements of the Plan of Implementation of the World Summit on Sustainable Development.

66. During its second cycle, in 2006 and 2007, the Commission on Sustainable Development will consider the thematic cluster that includes energy for sustainable development, atmosphere/air pollution, climate change and industrial development. At its fourteenth session, in 2006, the Commission will conduct a review of all four areas, identifying successes and best practices as well as gaps and remaining obstacles to full implementation, to be followed by

its fifteenth session in 2007, which will focus on policy options to further advance, among other things, the use of renewable sources of energy for sustainable development.

Notes

[1] *Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August-4 September 2002* (United Nations publication, Sales No. E.03.II.A.1 and corrigendum), chap. I, resolution 2, annex.

[2] See resolution 55/2.

[3] The World Solar Programme 1996-2005 encompasses all forms of renewable energy, including solar thermal, solar photovoltaic, biomass, wind, hydro, tidal, wave, ocean thermal and geothermal.

[4] Biofuels are renewable fuels of biological origin, such as fuelwood, charcoal, livestock manure, biogas, biohydrogen, bioalcohol, microbial biomass, agricultural waste and energy crops. Bioenergy is energy generated through biofuels.

[5] A/60/82, annex.